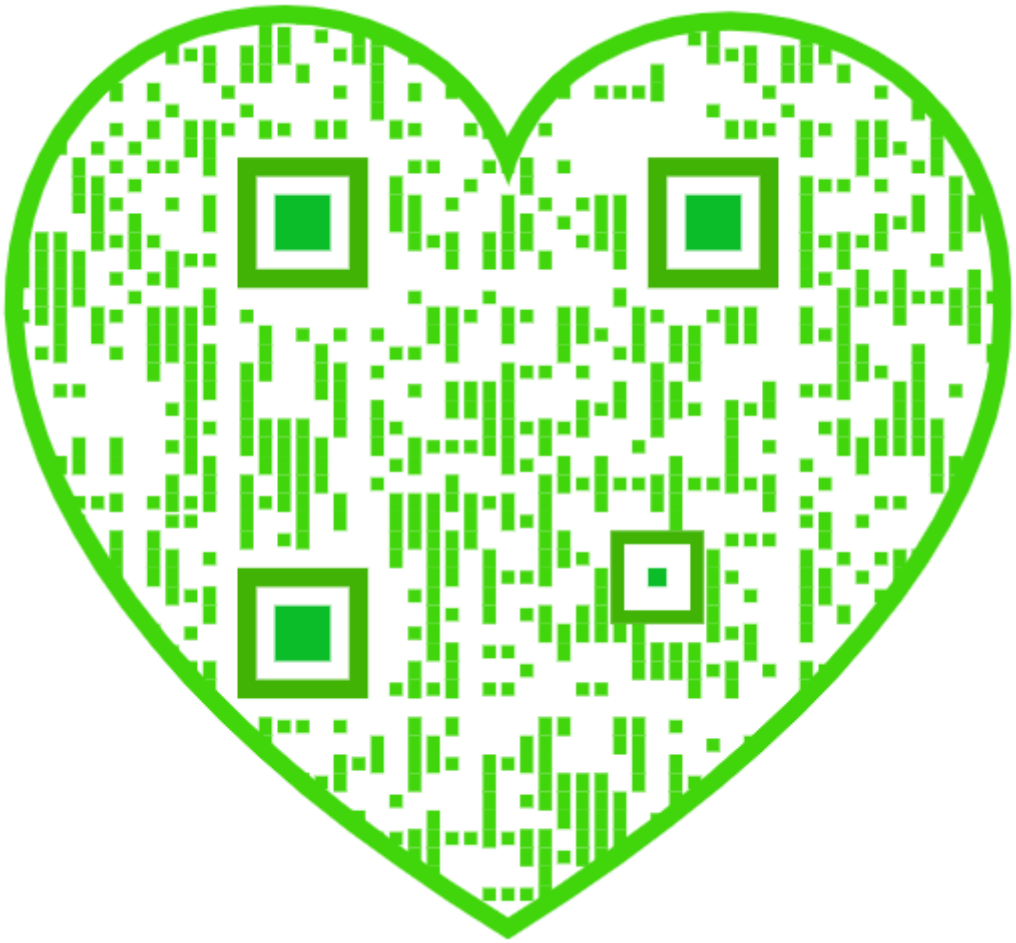

ZEPPELINS AND SUPER-ZEPPELINS

BY R. P. HEARNE

WITH TWENTY-FIVE ILLUSTRATIONS

LONDON: JOHN LANE, THE BODLEY HEAD
NEW YORK: JOHN LANE COMPANY. MCMXVI

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INTRODUCTION

When the Great War comes to be analysed it will be found that Germany owed much of her power to the amazingly developed technical skill which supported her armies. But for this scientific equipment, attack would have been in vain and resistance short-lived. Unfortunately the war has brought to light on the side of the Allies many instances of neglect upon our part, where through ignorance, indifference, self-satisfaction, or conservatism we failed to keep abreast with our rivals in the technique of war.

In the matter of aeronautics something very little short of a miracle saved this country from being without military aeroplanes when the war broke out, for only after long years of agitation in press and public were the higher authorities moved to employ the new arm. But when it came to adopting airships little headway could be made. The aeroplane enthusiasts themselves helped to create a prejudice against the airship, with the result that over a term of years we frittered away

large sums of money in timid experiments and in buying airships from other countries—including Germany—rather than take the bold step of striking out on a proper scale for ourselves.

Germany had gone to the other extreme, for, led away by hero worship of Count Zeppelin, she based absurd hopes on the crude vessels designed by this old soldier. The anti-airship experts pointed with glee to each failure of the Zeppelins, forgetting that every new mechanical development is brought about only by trial and error. They were foolish, too, in believing that Count Zeppelin alone possessed the secret of building airships.

As I point out in this little book, the rigid airship now represented by the Zeppelin was originally a French invention, and probably the Germans stole the idea. We can thus dismiss the common prejudice against the rigid airship that it is a German conception, and at the same time we should disabuse ourselves of the idea that Count Zeppelin's way is the only way and the best way of making a high-speed airship.

The Zeppelin raids upon England may help to change the official and the public view. It is stupid policy to abuse an instrument which does one an injury. In war we must not allow an

enemy to have any technical advantage. Each new device of his must be countered by something better, or, at least, equally good.

It is still debatable whether the Zeppelin of to-day is of any great military value, but it certainly has caused widespread death and damage in England, whereas we had no means of invading Germany by night. No man, and least of all the ignorant or prejudiced man, can prophesy what the future will bring in airship development.

As I shall show, the best way of fighting Zeppelins is to meet them in the air with superior airships. Seven years ago, as a result of what I had seen in Germany, I urged the building of rigid airships in this country. Had that advice been followed we might have saved hundreds of British lives, and we could have beaten Germany in the air as decisively as we did at sea in 1914. Our airships would have kept England free from invasion from Zeppelins; and carrying the night war into the enemy's country we could have done much damage to Krupps', to the Rhine bridges, and to the German camps.

From the technical point of view the Zeppelin has achieved extraordinary and unparalleled feats in aerial navigation since the war commenced, but

the ignorance of the British public on the matter is well illustrated by the pronouncement of an engineer, who as late as December, 1914, asserted that no Zeppelin could reach England owing to the aerial eddies from our hills, cliffs, and tall buildings!

The Zeppelins have come, and they have given us a rude awakening. But the Germans have fouled the new science of aerial navigation by the beastly uses to which they have put their ships. In bombing open towns, and in killing civilians they have shown a stupidity as gross as their blood lust. To protest is useless; and the moral holds good for future wars as well as for that of 1914. We must be forearmed.

In this book I seek to rouse popular interest in airships as distinct from aeroplanes. I look forward to the time when gigantic airships will serve us in peace as in war. The aeroplane cannot wholly solve the problem of aerial navigation, and the lesson of the Zeppelin raids teaches us the folly of allowing a rival nation to develop an engine of war which we dismiss with contemptuous criticism and half-baked theories based on prejudice.

In some respects it is fortunate for us that

Germany made war in 1914 rather than four or five years later, for most assuredly her airships then would have been more numerous and more highly developed, whilst we might be as ill-provided as in 1914.

There is strong internal evidence to show that Germany did not seriously reckon on our taking part in the war so promptly. But if the Germans were planning a war directly on us in 1920, or even in 1914, they would probably open the campaign with a massed night attack on London. During August, 1914, they could have wrought immense damage on the wholly undefended capital, for the crime was neither expected nor prepared for by us.

Germany has shown her hand now, and we must take the warning to heart. By good luck we have escaped very lightly from a peril which under other circumstances might have caused us really serious military loss as well as poignant suffering. The humiliation of the raids on London should stir us to take the most ample precautionary measures.

As this book is produced in war time it is necessary to omit any matter which might be of service to the enemy, though I must sorrowfully

admit that we have little to teach Germany, and much to learn from her in all that pertains to airships.

My object in issuing the book now is to urge on the British public, and through them the British Government, to take up the work of airship construction on a scale which will ensure safety and success for us in future wars. We have lost much prestige through the Zeppelin raids over London, and whilst that humiliation is hot we must resolve not to be caught napping again. Our neglect of airships is symptomatic of many other technical defects for which we paid heavily in blood when the hour of trial came.

In my book, "Aerial Warfare," published first in 1908, I called attention to the development of the Zeppelin, and the dangers of raids upon England were clearly pointed out. Many people will now regret that the advice given was not acted upon by the authorities responsible for the defence of this country. But even in November, 1915, in the sixteenth month of the war, Mr. Balfour had to admit that our aerial defences were still lacking in guns and other essentials. This little circumstance shows up a characteristic weakness. Foresight is evidently

not a virtue of British officialdom, and thus I do not feel it premature now to agitate for super-Zeppelins even though they may not be needed until the "next war."

To deal properly with aerial warfare we require a complete departure from the methods which brought trouble to us in 1914-15. The Air Service needs liberal endowment and unstinted equipment, and it must have the best brains of the country behind it.

Apart from the problems of this war, the Zeppelin is of special importance to Britain. I am convinced that the future of the super-Zeppelin lies over the water. When we have great sea-going aircraft capable of travelling at 100 miles an hour, with a range of action of 1000 or even 2000 miles, and when these powerful ships can carry shell-firing guns, aerial torpedoes, and several tons of bombs, it is evident that they will be of great potentiality to a maritime country.

There is nothing impossible in the points I set forth. The latest naval Zeppelin has a speed of from fifty to sixty miles an hour, a range of action of 700 miles, and a munition load of about four tons. If we set our mind to it we can build

CONTENTS

CHAPTER		PAGE
	INTRODUCTION	v
I.	IS THE ZEPPELIN A FAILURE?	1
II.	THE PRINCIPLES OF THE AIRSHIP . . .	14
III.	THE HISTORY OF THE ZEPPELIN . . .	32
IV.	THE CONSTRUCTION OF THE ZEPPELIN . .	42
V.	THE SCOPE AND LIMITATIONS OF THE ZEPPELIN	65
VI.	THE ZEPPELIN IN WARFARE	87
VII.	HOW TO FIGHT THE ZEPPELIN . . .	114
VIII.	AIR RAID PRECAUTIONS	134
IX.	SUPER-ZEPPELINS AND SUPER-AEROPLANES . .	144
	INDEX	157

LIST OF ILLUSTRATIONS

	PAGE
How the Density of the Atmosphere affects an Airship	21
How an Airship rises	25
Remarkable Records made by Zeppelins in 1912 and 1913	41
The Three Types of Airship	43
The Zeppelin Gondola or Car	53
The Zeppelin Incendiary Bomb	67
The Headquarters of the Naval Zeppelins	69

ZEPPELINS AND SUPER-ZEPPELINS

CHAPTER I

IS THE ZEPPELIN A FAILURE?

ON the night of September 8th, 1915, several millions of Londoners had their first experience of aerial warfare. They were brutally awakened from delusions which had possessed them for many years. Overhead were the mythical Zeppelin airships which had been proved failures by so many experts; and from these airships bombs were being dropped on London.

It was an awe-inspiring sight, but soon one felt consumed with anger and shame that the capital of the British empire could be thus attacked, and that helpless men, women and children could be murdered without the immediate punishment of the criminals.

garrison cities of Germany after London had been attacked, and no doubt the Germans

THE ZEPPELIN MENACE TO EUROPE.

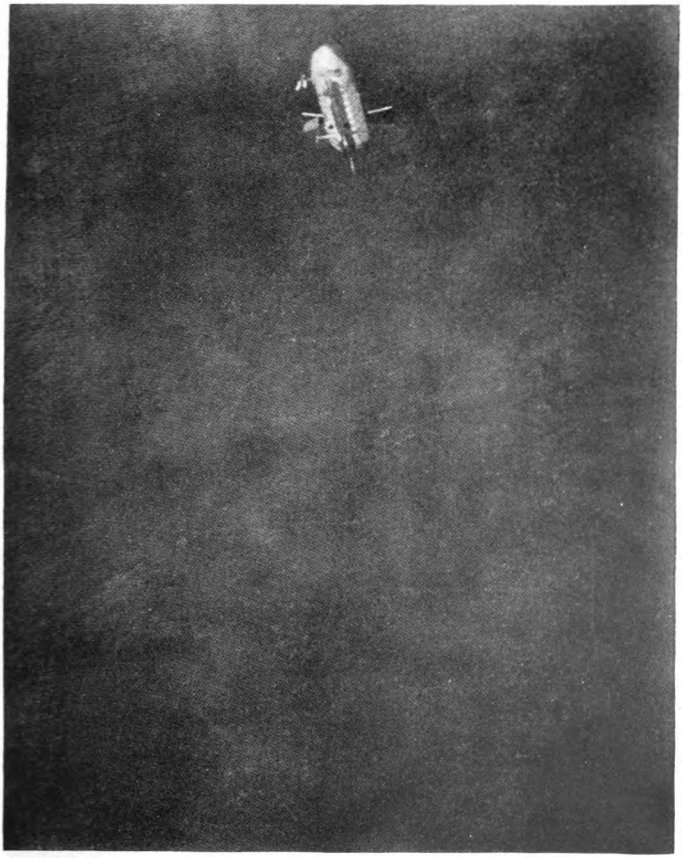
The shaded portions show the regions which can be raided by Zeppelins from existing bases. With new harbours in Belgium, Poland, and other captured territory the range of action can be extended considerably.

of soldiers altogether. The peoples are at war, and they fight with money, nerves, ideas, rumours, fears and hopes as well as with men and guns.

In their brutal, clumsy way the Germans have been groping after this principle of psychological influence, and this explains their murderings and brutalities. With certain races and temperaments these excesses are calculated to break down resistance, but luckily the more virile people are only stirred to greater resistance.

Bravery, however, by itself is of little avail against a well-armed adversary. To shake your fist at a Zeppelin is not the way to beat them out of the air. You must draw level with Germany in the technical side of the war if you are to defeat her, and we can trace neglect of this principle in the many costly deficiencies which cropped up in the Allies' equipment under the searchlight of war.

We cannot afford to lose a single life or a single penny to the enemy unnecessarily. When a Zeppelin bomb kills a woman, it kills a potential mother ; when it kills a child it leaves us short of a potential soldier or a future mother. Every house damaged is money lost. The



By courtesy of *"The Illustrated London News"*

THE ZEPPELIN AT NIGHT

The genuineness of this untouched photograph of a Zeppelin raider over the Eastern counties of England is vouched for by the Editor of "The Illustrated London News," and it forms an unique photographic record

greater losses. The reduction of lights in London on account of Zeppelin raids increased the street traffic fatalities by over one hundred per cent. In one week of November, 1915, twenty-five persons were killed. The normal average was six per week. During six weeks of October and November, 1915, over 120 people were killed, or a greater number than the official total for the Zeppelin raids on London up to that time.

The quibbling argument has been put forth that there has been little actual increase of traffic accidents "after dark." But in effect night traffic was reduced to a minimum owing to the excessive danger and delay experienced, and as a result the traffic at other times, especially at dusk, became congested, disorganised, and thus abnormally dangerous. The lighting restrictions were the real cause of the trouble, and these restrictions were adopted because at first we could do little more than hide ourselves from the Zeppelins.

It would be most erroneous to read from this that our authorities are making no efforts now to beat Germany in the air. In this chapter I am merely dealing with the question, "Is

the airship a failure?" on general lines, and I take the Zeppelin raids on England as examples of the effects which can be wrought by them. The argument could be applied to France or Russia also, with this difference that for us in this case the sea is a disadvantage rather than an advantage. For many reasons we are the choice target of the Zeppelins.

To reach France a Zeppelin must make an overland voyage, and thus be liable to detection either by sight or sound all the way. It must also cross the battle line, which in itself is the most concentrated barrier possible with land defence.

To reach England the Zeppelin travels over the North Sea, with little risk of detection. The British coast is not a battle line studded with guns, and in fact we have to set up a special defensive system to deal solely with aerial craft. This organisation detaches men who otherwise might be used in the main campaign, and one Zeppelin with a crew of ten men may require several thousand watchers to guard against it.

Scores of reasons, military, strategic, moral, economic and commercial, could be advanced to

of the war? They were naturally anxious to be upon the winning side, and they seized upon every scrap of evidence to estimate how the war was going. Is it not probable that distorted German accounts of raids upon London, supported by the clumsy official admissions from British sources, helped to create the impression that Germany was winning? The neutral who visited darkened London and gaily lighted Berlin must have noted a strange contrast all in favour of Germany, and in the superficial manner of the traveller he could easily give false values.

In addition to grimly preparing for this war during many years, it is evident that Germany paid attention to the process of stage-managing the campaign. If the Zeppelin has been of no direct military value in killing off great numbers of soldiers, it has helped to create on neutrals and on ignorant and fearsome people the idea that Germany was omnipotent. The turn of affairs in the Balkans in the autumn of 1915, closely following the Zeppelin raids on London, is but one example of the influence which may be traced to this stage-management of the war.

Success in modern war is made up of an

immense number of elements, and Germany's extraordinary power is in itself a striking example of the importance of organisation, enterprise, and scientific development. These were opposed by the most glorious sacrifices, many of which could have been avoided if other nations had been equally alert in military technique.

The Zeppelin airship has been making its way to practicability for over ten years, and yet in that period no other nation made any serious effort to prepare against it. They started off with the settled theory that it was impracticable. So, too, in my own time I have heard engineers and experts of various kinds prove that the bicycle, the pneumatic tyre, the petrol motor, the motor car, and the aeroplane were mechanical fallacies. Up to the time when a Zeppelin made its appearance over England there were learned wiseacres who proved on paper that no Zeppelin could ever reach this country.

The most important matter now for the public is not to be stampeded with absurd ideas about the powers of the Zeppelin. It generally happens that the converted sceptic is a panic-monger. We must weigh up the

powers and limitations of the airship fairly, paying due attention to future developments, however. A calm survey on these lines will help us best to realise the full extent of the Zeppelin menace, and at the same time it should stimulate the authorities entrusted with our safety to act vigorously.

It is folly to persist in the old belief that the airship is a failure. It might be argued equally from the war of 1914–15 that cavalry were a failure, so small was their influence ; and yet it would be madness to give up this arm. A little fleet of air vessels could not possibly influence the course of the war, but when we are free to fully reveal the work done by Zeppelins in the Great War, both in raids and in scouting over land and sea, it will be demonstrated that our lack of airships cost us very dearly in lives, prestige and money. The Zeppelin helped to make victory difficult for us in more ways than one.

CHAPTER II

THE PRINCIPLES OF THE AIRSHIP

A GENERAL knowledge of the principles of the airship is advisable before we come to details of the Zeppelin. Aerial vessels may be divided into two great classes :—

(1) Aerostatic, or lighter-than-air vessels, which derive their buoyancy from the use of gases lighter than air. Balloons, dirigible balloons, and "airships" belong to this class.

(2) Aerodynamic machines, or heavier-than-air vessels, which rise and travel through the air by mechanical means. Aeroplanes and flying machines belong to this class.

I need not dwell here on the principles of the flying machine, for they are now generally known, and are fully described in many excellent text-books. It is well to bear in mind that the flying machine can remain aloft only as long as it is being driven through the air at high speed. Thus, in effect, it depends upon its engine. I may also point out that the airship

or dirigible balloon can partake of the character of the aeroplane by fitting planes, and these planes actually serve to elevate or depress the airship just as an aeroplane is steered upwards or downwards.

The distinctive feature of the airship, as I shall call the lighter-than-air dirigible balloon, is that it can float in the aerial sea without any mechanical assistance. To understand the principle of the balloon or airship we must consider the air as a fluid, and then get a clear idea about the difference between the weight and the volume of a body.

Why an Airship Floats

In plain language we may regard the volume of a solid body as its size or bulk, and it is obvious that we may alter the volume or size of a body whilst its weight remains the same. Metal for example can be shaped as a solid mass or it may be so extended as to form a thin shell. A lump of steel will sink in water, but roll that steel out into thin plates and you can make a boat or vessel which will float.

The essential difference between the lump of steel and the boat is that whilst the *weight* remains

the same the *volume* has enormously increased. Now, when a body is immersed in a fluid it displaces a *volume* of fluid equal to its own *volume*. The lump of steel displaces very little water : the steel boat displaces a large volume. The lump of steel is heavier than the small volume of water it displaces : and thus it sinks, for a fluid cannot permanently support a body heavier than itself. But the steel boat is lighter than the large volume of water displaced, and thus it rides on the water. Fill it with water, however, and it sinks.

Fluids arrange themselves in layers according to their density or weight. Hence the lighter cream floats on the surface of milk. Warm water floats above cold water, for an increase in temperature increases its volume. Water at the bottom of a deep sea is heavier or denser owing to the pressure of the upper layers.

In a similar manner the air is made up of different layers, the light airs being above the heavy strata. Air at sea level is generally the densest and the heaviest because it is at the bottom of the aerial sea.

Confining our attention now to the phenomenon of flotation, we can understand from the water

than the total weight of the ship. Comparing the weight of a cubic foot of air, coal gas, and hydrogen, we have :

Air	...	0·080 lbs.	per cubic foot, or	16 lbs.	per 200 cubic feet.
Coal gas	...	0·040	„	8	„ „
Hydrogen...		0·005	„	$1\frac{1}{10}$	„ „

Thus if we had a toy balloon of 200 cubic feet capacity, which weighs when empty 3 lbs., it would *weigh* $1\frac{1}{10}$ lb. more when filled with 200 cubic feet of hydrogen. When thus filled the balloon would weigh in all $4\frac{1}{10}$ lbs., and it displaces 200 cubic feet of air, weighing 16 lbs.

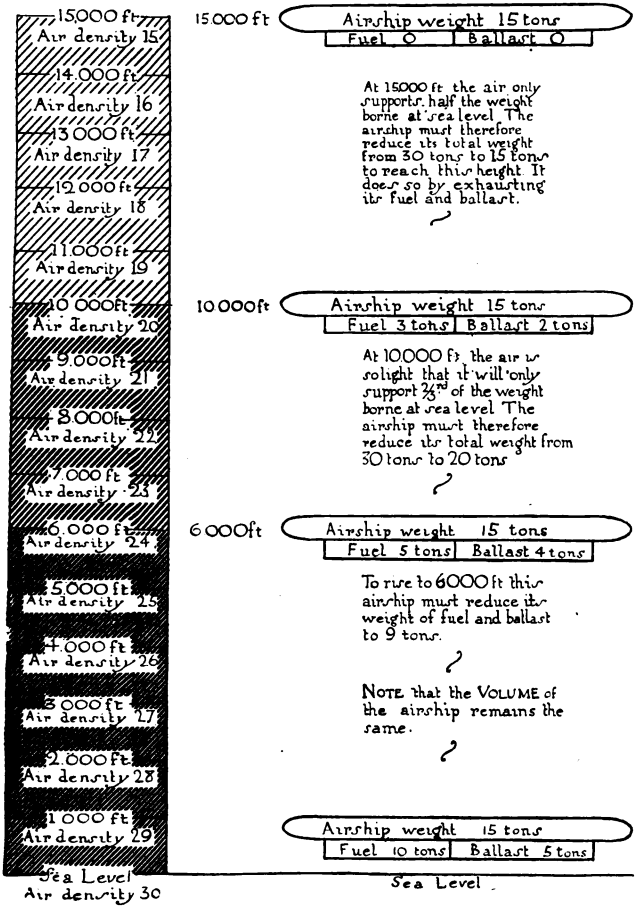
A balloon of this size would consequently have a lifting power of about 11 lbs. ; or it would rise until the density of the air was such that 200 cubic feet of displaced air weighed only $4\frac{1}{10}$ lbs., when a state of equilibrium would be attained.

The atmosphere varies in density or weight according to height. At the surface of the earth a cubic foot of air weighs more than a similar volume at 1000 feet, and the higher we ascend the greater is the difference in weight. In round figures the air decreases one-thirtieth in weight for every thousand feet we ascend. At 10,000 feet

Another feature of the gas used in airships is its diffusive power. Hydrogen will leak through any substance employed for gas envelopes, and this leakage is important in many respects. An airship gradually loses its gas by diffusion, and thus the buoyancy of the ship decreases. As this gas leaks from almost every pore of the gas bag and mixes with air it forms a highly inflammable mixture or atmosphere around the vessel, and this aura has been the cause of many airship disasters.

The flotation of the airship is a delicate affair, depending, as we have seen, on many circumstances. The ship's captain has some control over his altitude, as by allowing gas to escape he sinks, whilst by throwing out ballast he rises. In the older airships the gas was allowed to waste, but on the modern Zeppelins there is a most ingenious system whereby gas taken from the bags is stored in metal vessels under pressure, and reserve supplies of gas can be carried also.

In this way the Zeppelin can remain longer in the air than other airships, and it has a wider range of altitude. By discharging ballast or by increasing the volume of the gas bags it can rise: and by decreasing the volume of the gas bags it


15,000 ft
Air density 15
14,000 ft
Air density 16
13,000 ft
Air density 17
12,000 ft
Air density 18
11,000 ft
Air density 19
10,000 ft
Air density 20
9,000 ft
Air density 21
8,000 ft
Air density 22
7,000 ft
Air density 23
6,000 ft
Air density 24
5,000 ft
Air density 25
4,000 ft
Air density 26
3,000 ft
Air density 27
2,000 ft
Air density 28
1,000 ft
Air density 29
Sea Level
Air density 30
15,000 ft
Airship weight 15 tons
Fuel 0
Ballast 0
At 15,000 ft the air only supports half the weight borne at sea level. The airship must therefore reduce its total weight from 30 tons to 15 tons to reach this height. It does so by exhausting its fuel and ballast.
10,000 ft
Airship weight 15 tons
Fuel 3 tons
Ballast 2 tons
At 10,000 ft the air is so light that it will only support 2/3rd of the weight borne at sea level. The airship must therefore reduce its total weight from 30 tons to 20 tons
6,000 ft
Airship weight 15 tons
Fuel 5 tons
Ballast 4 tons
To rise to 6000 ft this airship must reduce its weight of fuel and ballast to 9 tons.
NOTE that the VOLUME of the airship remains the same.
Airship weight 15 tons
Fuel 10 tons
Ballast 5 tons
Sea Level

HOW AN AIRSHIP RISES.

The airship fully loaded is lighter than an equal volume of air at sea-level. It is held down by weights and extra ballast. The ship rises by casting off these burdens. It also grows lighter by consuming fuel. At higher levels the air has less supporting power, and, to rise, the vessel must continue reducing its weight.

volume. This enlargement of the air bag and compression of the gas bag would make the balloon as a whole heavier, for in relation to hydrogen we must consider air to be a very heavy fluid.

In the non-rigid type of airship the outer envelope of fabric is inflated from a shapeless mass, and it holds its shape solely by this inflation. As the gas inevitably leaks the ballonet comes into action, and the air bag helps to keep the outer envelope from becoming flabby. Of course, as time goes on the airship loses buoyancy or sinks, for the gas bag is leaking and shrinking and the air bag is expanding with a heavy fluid.

The essential difference between the Zeppelin or rigid airship and the non-rigid or gas-bag type is that the Zeppelin has a stiff carcase which being of metal always retains its shape. Within it are the gas bags. The non-rigid airship is, however, merely a fish-shaped balloon made of fabric and kept in form by gas pressure.

Types of Airships

Airships may be divided into three classes :

(1) Non-rigid, or gas bags, in which the envelope is collapsible.

travel longer distances, and face stronger air currents than the other types. The rigid airship is the only type offering any possibility of serious development. The other types are obsolete when judged by the speed test.

In considering speed and power we must bear several things in mind. Firstly, to take up a big engine we must have a ship of considerable lifting power, and this can only be attained by building a large ship of ample gas volume. Constructional difficulties wholly prevent a non-rigid or semi-rigid ship from being designed on a grand scale, for we must remember that it keeps its shape only by gas pressure.

A long gas bag of this type when subjected to cross currents of air or other strains is very liable to collapse. Again, if this type of vessel be forced through the air at high speed it is liable to deformation by the air resistance. Hence the non-rigid ship is limited in size, and thus is limited in engine power and in speed. To force any ship through the air at high speed demands much energy. A long slim body meets with less resistance than a broad or fat body. The Zeppelin can be built of great length and slimness, whilst other airships must be made short for reasons of strength and

must be built deep and broad to contain a reasonable volume of gas. But their size and volume are limited. Thus in lifting power as in speed they are inferior.

As the desire for speed and power grew it became evident that the non-rigid ship, owing to its limited size and lifting capacity, must become obsolete ; but so conservative were many designers that they would make no advance. The airship became more of a military machine, and less of a sporting or commercial affair, and military designers are notoriously reactionary in their ideas. Ten years ago it became an almost settled affair that Germany should build rigid-ships, France semi-rigids, and Britain non-rigids ; and with little civilian stimulus (save in Germany) to help on development the progress has been relatively slow.

England pig-headedly adhered to non-rigid airships until eventually by dint of public agitation the authorities were compelled to buy a few semi-rigid vessels from France and from Germany. A hasty attempt was made to build a rigid ship on Zeppelin lines, but the vessel broke its back on its trial trip and the discouragement evidently damped further activity.

Some success has been claimed recently for

CHAPTER III

THE HISTORY OF THE ZEPPELIN

THERE is irony in the circumstance that the Zeppelin airship is really a French invention. Had this fact been known to the French nation ten years ago things might have been very different to-day. For when the idea was held that the Zeppelin was a German affair the French were too proud and too prejudiced to copy it, and the British experts of the day, sitting at the feet of the French in all that concerned aeronautics, would believe nothing good about this German contrivance.

A campaign of bitter prejudice was waged by ill-informed French and British experts against the Zeppelin, and the French aeroplane was held to mark out the only true course in the evolution of the aerial vessel. With typical German obstinacy Count Zeppelin worked on, and ultimately the German nation, perhaps in a spirit of international rivalry, supplied funds most

a capacity of 400,000 cubic feet. This gave a gross lifting force of eleven tons. The net lifting power after allowing for engines, fuel, gear, etc., was about two tons.

The frame of the vessel was made of aluminium lattice work, divided into seventeen compartments, fifteen of which had gas bags. The outside of the frame was covered with strong fabric. A triangular aluminium keel gave strength to the whole structure. Two cars were attached to the keel, and in each was a 16-h.p. German Daimler petrol motor driving two propellers mounted at the side of the ship.

Unlike other designers in later years Zeppelin was able to put his first airship in motion without a structural collapse. Starting from the surface of Lake Constance in July, 1900, the first Zeppelin made its trial trip very successfully, although many minor troubles were revealed and a few mishaps occurred. But it was really a great achievement. The ship attained a speed of over fifteen miles an hour, a speed which ten years later was barely attainable by the latest airships built in other parts of Europe!

As it happens in many inventions, the full difficulties were not realised until the first half

In a sense the incident threw some light on the strained relations then prevailing in Europe, and certainly something more than sympathy for an inventor led the German people to act as they did. Within twenty-four hours of the disaster the German Government had made Count Zeppelin a grant of £25,000 so that he might continue this work; and public subscriptions very soon raised a fund of about £100,000. Three months later the German nation had supplied Zeppelin with £300,000, and with this money he set out to build at Friedrichshafen the airship works which were soon to grow world famous.

From what we know now it is evident that in 1908 the leaders of opinion in Germany were preparing for the great war, and in the Zeppelin they saw a most useful ally which through the prejudice of foreign critics was discredited in other countries. Germany in effect had a virtual monopoly in rigid airships, and the Germans by long trial knew that this was the best type of airship, whereas the theorists and officials in other nations had no such practical guidance, for most of them had never seen a Zeppelin.

In 1909 during a visit to Germany I was astounded at the preparations which were being

made there. At Friedrichshafen the new Zeppelin works were in rapid progress, the ground site being over 300 acres. Everything was planned on a gigantic scale, and as far as possible the works were self-contained so that almost every process of construction could be carried out on the spot. Even then the estimated output of Zeppelins was placed at five per annum, and the provisions for expansions were such that in case of need the number could be greatly increased.

At the same time in various parts of Germany other work was going on which had relation to these developments. Airship harbours were being constructed at the military centres and other strategic points on the eastern and western frontiers. The first steps were being taken also for the harbouring of naval Zeppelins at Heligoland, Emden, and Kiel—from which places, six years later, set forth the Zeppelins which raided England.

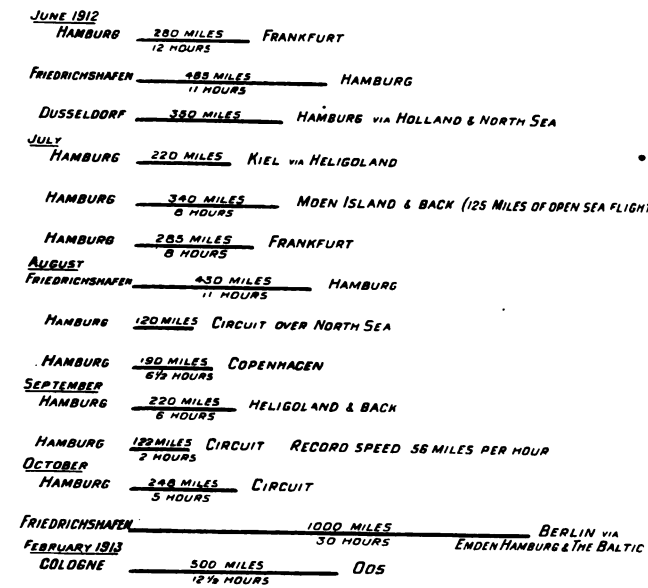
Yet another branch of German preparation was the institution of weather stations all over Germany so that special reports could be prepared for the guidance of aerial pilots. I feel sure that this work was carried into other countries also, giving the Germans a mass of most useful data

on the weather conditions in France, Russia, and England for example. The scale upon which the work was done and the unstintedness of the expenditure were amazing, especially when I contrasted the conditions of affairs in France and at home.

On my return I made every effort to rouse official and public opinion, but I could get little hearing. France and Britain were obsessed with the aeroplane just as Germany was obsessed with the Zeppelin. The experts were so biassed that most of them took sides, and developed that most intolerant of all prejudices, the blind conviction of the partisan theorist who ignores facts. For some time in Germany there was the same prejudice against aeroplanes, but very soon this was adjusted, and Germany was able to build a complete aeroplane of her own at a time when England had still to depend on France for her engines and on Germany for fabric to cover the planes.

It was the sporting instinct of the Britisher which saved the situation for us as regards aeroplanes. Our sportsmen brought in American and French aeroplanes, helped little factories to be set up, and kept the industry going until the tardy

and Russia the Zeppelins were not really necessary. But in a war with England matters would be wholly different. So it was that when England declared war a period of feverish activity set in



REMARKABLE RECORDS MADE BY ZEPPELINS IN 1912 AND 1913.

The longest distance travelled was 1000 miles, with halts for replenishment. The highest average speed was 56 miles per hour, for two hours. But on other occasions an average of 42 miles per hour has been maintained for more than ten hours.

at the Zeppelin works, and the new ships were expressly prepared for action against England. But it was too late to act on a grand scale in 1914.

CHAPTER IV

THE CONSTRUCTION OF THE ZEPPELIN

IT is at once a fault and a merit of the Zeppelin that the design has not radically altered since the first plan. The original Zeppelin was in its day a most remarkable structure, and from whatever source he was inspired, Count Zeppelin achieved a triumph unequalled in aerial navigation. But in strictly adhering to that design in the light of later knowledge Zeppelin has shown stupid conservatism.

The first airship was in the shape of a prism with twenty-four sides, and it measured 410 feet long by 37 feet in diameter. In appearance it resembled a gigantic vegetable marrow, and it maintained its shape by the aluminium lattice work which composed the skeleton. Seventeen compartments were formed to strengthen the structure by their walls and provide accommodation for the separate gas bags. But for these cross members the Zeppelin might be regarded as

Great ingenuity was shown in the design of the girder and lattice work, and by long experience the whole structure was made much stronger and lighter in the later ships. A most important feature was the metal keel which formed a spine and helped considerably in stiffening the structure; but as this keel had to be cut away in parts to fit in the cars its efficacy was reduced. Many improvements have been made in the composition of the metal employed for the framework, and in the modern vessels a very satisfactory compound of aluminium is used.

Save for minor variations the modern Zeppelin follows on the original lines, although in some of the ships an attempt was made to introduce a central tube for bracing the frame along its entire length. This important innovation was not generally adopted owing to the trouble it entailed in the gas chambers.

Originally each compartment could be completely filled by its gas bag, and this had a filling valve underneath and a release or safety valve on top. This arrangement was very simple and effective, and the utmost buoyancy could be obtained. A central spine running through each compartment set up many complications which

heat, protects the gas bags from sudden changes of temperature. A balloon is very subject to these changes, heat producing rapid expansion and increased pressure of the gas, with liability to bursting of the bag, whilst cold sets up contraction, causing the ship to sink. So sensitive is the ordinary balloon to changes of temperature that passing through a cloud alters the altitude of the vessel.

The heat of the engines can also be utilised to keep up the temperature of the Zeppelin air jacket. In this manner the vessel acquires and maintains greater buoyancy than otherwise. The heated air is lighter than cold air, and it maintains the temperature of the gas also. It is doubtful if this important feature is to be found on all the Zeppelins, and many changes and modifications have been made. With proper precautions the hot exhaust gases from the engines could be employed, but a simpler system is to use hot air. In either case a considerable improvement is effected, and this feature is of great importance in future airship design.

In the Zeppelin the gas is not maintained at any great pressure, but the non-rigid dirigible must have good pressure of gas and air, as it

propelled by mechanical power we have a simple gas bag inflated with hydrogen, coal gas, or some other gas lighter than air. This gas is very sensitive to various agencies. Heat causes it to expand, and if the gas is contained in a closed envelope of small strength the pressure may burst it. Cold, on the other hand, causes contraction of the gas volume and the envelope becomes flabby.

Thus it may be said that heat causes an airship to rise, since the gas bag increases in volume without increasing in weight. Cold leads to a descent, for the gas decreases in volume and so displaces less air. But there is yet another force at work—air pressure. At sea level this pressure is normally greatest, and it tends to check the expansion of the gas in the balloon or airship. But as the ship rises high in the atmosphere the air pressure declines, and consequently the gas has greater facility for expansion. This expansion, however, is controlled to some extent by the fact that at higher levels the temperature decreases and induces contraction of the gas.

The net effect of all these actions is that a simple balloon or airship is subjected to great and frequent variations in gas volume and consequently

The Zeppelin Control System

To remedy this very crude system of altitude control Zeppelin slowly perfected his automatic system. Each gas bag in the Zeppelin is connected to a supply pipe and also to a pressure pump which leads to a metal storage tank. Below the gas bag is an air bag connected with an air pump. An elaborate system of gauges, automatic valves and controls complete the equipment.

At the commencement of the journey the Zeppelin gas bags are not quite filled with gas at low pressure. In the metal tanks is a reserve supply under considerable pressure. The air bags are partly filled to keep the vessel heavy at its moorings, but as the ship is released the air is allowed to escape, and by this means the gas bags gradually expand, their *volume* increasing. As the light hydrogen replaces the heavy air the ship grows lighter, and rises.

The air bags also enable the ship to be tilted, for air can be pumped into some of the rear bags, making the back of the ship heavier than the front. With the nose tipped up and the engines driving the ship steers upwards rapidly.

Fully loaded as it is at the outset of the

gondolas. A photographic compartment is also provided. Here the photographs taken during the voyage are quickly developed and printed. The scientific instrument equipment is very elaborate, and along the keel corridor are neatly arranged spare parts, tools, ropes, and other supplies.

Each gondola is an engine room, the petrol engines working through variable gear boxes to drive shafts which run up to the side of the ship, where the propellers are mounted. This form of power transmission is very efficient in itself, but the construction of the ship does not allow the energy to be used in the best manner. The arrangement of the gondolas is most methodically carried out, the attention to detail being simply marvellous. As an object lesson for engineers in weight saving a Zeppelin is worth its cost to any nation.

On the subject of the Zeppelin engines a great deal of nonsense has been written, and the estimates of engine power are usually fantastic. Almost from the first the Zeppelin has employed the famous Daimler-Mercédès motor, made in the works founded by Gottlieb Daimler, to whose genius we largely owe the petrol motor. From

Germany ahead of the world, for she had come to a stage of standardisation which was in contrast to the constantly varying types used by the other nations. The German engines were of the stationary type, whereas France favoured the more delicate rotary engine, and set the fashion for England until British manufacturers tardily stepped in.

For some years before the war German aeroplanes had gained many triumphs, especially in long-distance events, and these gave evidence of the thorough testing of the engines. The Zeppelins, too, were steadily increasing their speed and range of action. Then came a curious circumstance.

After neglecting motor-car racing for some time the German Mercédès cars successfully competed for the French Grand Prix race in 1913 with engines of which the details were most jealously guarded. In July, 1914, hardly more than a month before the war, the Germans again competed *in France* and defeated the French cars in a sensational manner.

When the war had been many months in progress a German aeroplane, of the latest type, was captured by the French, and on expert

the ship. Naval ships are lettered L, and privately owned vessels are known by some name such as Hansa, Victoria—Luise, etc. Some confusion arises in the numbering owing to rebuilt ships receiving a new number. Only from the official German tables can we arrive at the number of substitute vessels. Usually the number of Zeppelins is much over-estimated, as the German authorities themselves are not above falsifying the figures.

ZEPPELIN TYPES

Type.	Mark.	Capacity (average).	Weight.	Total Lift.	Engines.	H.P.	Speed.	Length.
Military		cubic feet.	tons.	tons.			m.p.h.	feet.
Zeppelin.	Z	550,000	11	15	3	150	40	480
Naval . .	L	850,000	18	24	3	350	60	520
Private .	(name)	600,000	14	18	3	200	50	500

The actual weight of the ship includes the engines, fuel, equipment, ballast, and crew. The total lift represents the total weight which a ship of that gas capacity will lift. Speed is expressed in miles per hour.

Some of the latest naval ships have a gas capacity which gives a lift of 28 tons, engine power is in the region of 450 h.p., and the maximum speed is probably over 65 miles an

hour. The latest military ships now approximate to the earlier naval types in engine power and speed. All these estimates are only approximate, however, for they are based on German figures, and we know that German figures are not always exact. Still we have the evidence of our eyes that Zeppelins have grown in size, in power, and in speed.

Aerial Navigation

The navigation of an airship like the Zeppelin presents many new problems, and it does not follow by any means that naval men are the best fitted for the work. Aeronautical engineering and navigation call for a distinct class of men specially trained for the work. Count Zeppelin has found most of his best men in the ranks of the professional and amateur balloonists.

In sea navigation we are concerned with the movement of a vessel along a practically horizontal plane, and moving through a medium whose currents are slow and more or less well defined. There is above the sea surface the lighter medium of the atmosphere where strong winds can blow, but in the case of steamships the wind does not normally exert enough pressure to force the

vessel out of her course to any considerable extent.

All this is different with the airship. This vessel is wholly immersed in the flotation medium. The aerial sea is in constant motion, and in addition to variable currents flowing from different directions in the same horizontal plane approximately, we have powerful up-draughts and down-draughts to allow for.

An airship, with its engines motionless, would drift like a balloon with the current of air in which it is immersed. It might encounter other currents which would sweep it out of a straight course, or carry it upwards or downwards. At different altitudes the direction of the wind currents vary very considerably, and thus the course of a drifting airship could be most erratic.

These currents act on the airship when in motion also, and unless it has engine power or speed sufficient to force its way through strong currents the vessel will be at the mercy of powerful winds. It should be obvious from this that speed is the really vital factor in aerial navigation, and as no other class of ship can approach the Zeppelin in speed it follows that the rigid type is immeasurably superior to all others when in the air.

If an airship could average 100 miles an hour, she would be fit to take the air on any day of the year, for this speed would give her the power to travel in any direction. She could fight her way out of the strongest current likely to be encountered, and in the aerial sea it often happens that gales are quite local, some being widespread but low in altitude, others being narrow but high. In the navigation of the future, when an airship can run for hours at 100 miles an hour, and have a range of altitude up to 10,000 feet, the pilot will have ample opportunity for finding a safe track. Here it is that the aerial vessel scores over every other vehicle in that it has an illimitable number of tracks to choose from, always provided that it has speed sufficient to enable it to master any adverse current.

When an airship captain plans a journey he marks out his course from start to finish on his chart, usually in a bee line or direct course. He will then steer by compass and the guidance of the heavenly bodies, as in sea navigation. Like the mariner he must have landmarks also to check his locality by in order to correct the effect of drifting by the influence of side currents.

It is easy to understand that in aerial navigation this drifting is very important, for air currents have far greater speed than sea currents, and they may vary in speed and direction very frequently. Landmarks are thus absolutely essential for the air pilot.

If, for example, he is making for a point due north on his chart, he may set out in still air, and head directly for his objective. At any instant an invisible air current from the west may come upon him, or may be entered by him, and this may drift him many miles out of the direct way to his goal. He is always heading north, and yet he is sliding eastward also at an unknown speed.

Unless he checks his position by some landmarks he will be unable to correct his course. When he makes this correction he steers in a somewhat westerly direction so as to counteract the current which is carrying him eastward.

By daylight it is relatively easy for a skilled pilot, backed by a weather bureau, to make a very accurate course, and the Zeppelins with their pilots, balloonists, weather experts, and spies, aided further by the ship's wireless system, can find their destination with great certitude.

At night, however, conditions are much more

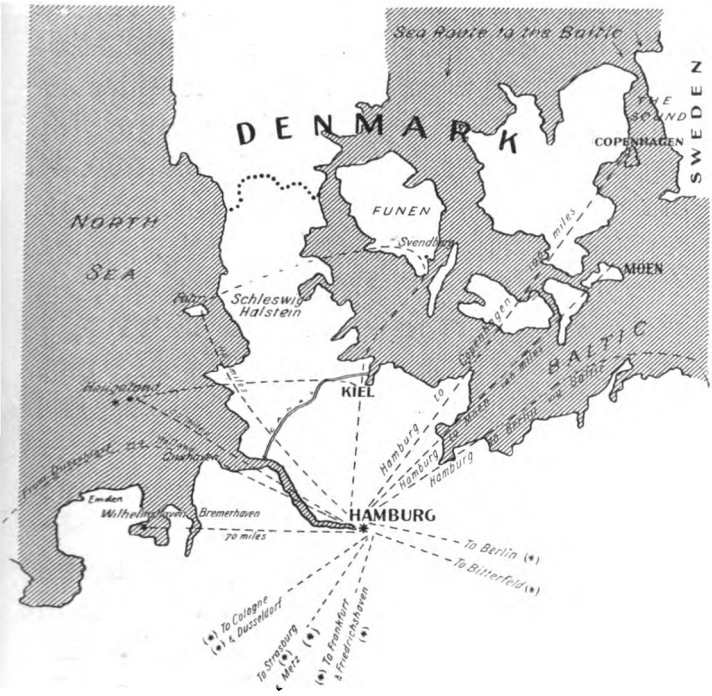
reckon on the prompt participation of England in the war, and she knows that British intervention has spoiled her chance of success.

The German is a bad loser, and he has an hysterical strain which incites him to blind rage and fiendish revenge. German hatred of England is so intense, especially as the war drags on, that any crime against England pleases the baser element of the German race. Murder raids on England have given extraordinary satisfaction in Germany ; and in addition to the gratification of revenge and murder lust, and the appeasing of national vanity, there has been a shrewd estimation of the effects upon neutrals. The Zeppelin raids on London during the autumn of 1915 were cunningly designed to influence the Balkans, and Germany, with her wonderful news organisation, was able to tell grim stories of London in ruins, and of a panic-stricken people helpless under the German bombardment.

The echoes of the bombs dropped on London were, so to speak, heard in the Balkans, and the many unfortunate effects which followed the raids show how dearly we paid for our helplessness. In these critical weeks if we had possessed a fleet of airships which could have routed the

LIMITATIONS OF THE ZEPPELIN

Zeppelins, or could have raided Germany, the whole situation might have been different.



* *Airship Harbours*

THE HEADQUARTERS OF THE NAVAL ZEPPELINS.

From Heligoland, Hamburg, Kiel, Wilhelmshaven, and Emden the Naval Zeppelins set forth for raids on England, and for scouting work in the North Sea and the Baltic. The dotted lines show trips which were made before the war.

In themselves the raids were minor incidents, but they furnished a fresh proof to wavering neutrals of Germany's power and superiority. For the Allies this was a most unfortunate circumstance.

Of course, when we come to consider the limitations of the Zeppelin we can adjust the popular estimate of the potentiality of the ship. In the first place, the Zeppelin does not get the best out of the rigid type of airship. Count Zeppelin set out with an imperfect design, and he has adhered to it with obstinacy. True, he has a far better design of ship than any other country, but nevertheless it is defective. It is not the time now to go into details, but I can indicate a few main points which are common knowledge in German airship circles.

This great Zeppelin tube, nearly five hundred feet long, is inherently weak in that it has no central stiffening running right through it. The triangular keel serves as a spine, but it has several defects. Consequently the Zeppelin is a fragile vessel, and its safety depends on the most skilful handling, learned by long experience.

In coming close to earth this immense mass is endangered by squalls and wind gusts, and if the weather is at all broken the margin of

safety for the ship is very small. Unfortunately for us, the Zeppelin is better fitted for oversea work than for land operations. In one sense this little fact explains why raids upon England have been more in favour than attacks upon France or Russia.

The inherent weakness of the Zeppelin design is always a source of danger, however, and the strains and stresses set up by a voyage in fair weather conditions entail a considerable amount of overhauling. All aircraft are delicate in this respect, and the amount of running time is but a very small part of the life of the structure.

With each Zeppelin we must, therefore, allow an ample margin for overhauls and repairs, and this margin must be increased when in war time long-distance raids are carried out in which enemy guns must be faced. Very high speed may then be entailed, and rapid and daring manœuvres be necessary for safety. It may be asserted that after one average raid a Zeppelin must go into dock for thorough overhaul, so strained is the structure by the exertions.

In this we have a limiting factor of no small importance, for it means that if Germany is to keep up a sequence of raids she must have

a big fleet. The wildest statements have been made as to the strength of the Zeppelin fleet, and at one time an idea was current that Germany was able to turn out new ships at the rate of two per month, or twenty-four per annum. Other estimators asserted that Germany had secretly built up a great fleet of Zeppelins before the war, and it was surmised that at the opening of the campaign Germany had fifty Zeppelins, and by 1915 this fleet had been increased to eighty!

At the same time casualty lists were invented which went to show that some twenty Zeppelins had been lost or captured during 1914–15. To the public and the average newspaper reporter every airship, or even a captive balloon, is a Zeppelin. Aeroplanes were also loosely called "airships," and so it was easy to advance another stage in the transformation and become "Zeppelins." War rumours are most undependable, and in technical matters the inexactitude becomes acute.

Hence the current estimates concerning Zeppelins have been grossly misleading. It must be remembered that Germany has several other types of airships, including another rigid type—the Schutte-Lanze. Thus even to the

German public there was haziness as regards the precise number of Zeppelins.

For many years the utmost capacity of the Zeppelin factory was one ship in a year, and work on the new vessel was often diverted to make urgent repairs to the old vessel in use. With the extensions of the factory and the development of the naval airship programme two ships were produced in the year, and from 1909 onwards the actual capacity rose to about five per annum. These figures were not always reached, however, for as the fleet grew, more time was required for overhaul and repair work on the old ships.

Since the commencement of the war the output of Zeppelins has been considerably increased, possibly being doubled. But the blockade by the British navy has set up an unexpected limiting factor; and the shortage of rubber, cotton, aluminium, copper, etc., cripples the work.

The Zeppelin Fleet

On the most liberal estimate, based on very searching records and data, I compute that in August, 1914, Germany had in all twenty serviceable Zeppelins, of which at most six were naval ships suitable for long-distance raids.

skilled labour of a strictly specialised type. No doubt if all had gone well with German plans in 1914, that is, if England had remained neutral whilst France and Russia were being crushed, there would have been Zeppelin production on an immense scale during 1914 and 1915, so that in the later war with England a really great naval Zeppelin fleet would have been available to open hostilities with. Then a sudden massed attack of twenty or more ships, delivering fifty tons of explosives on London, would be a stunning blow.

The Zeppelin resembles the great naval ships in that it cannot be improvised or its output suddenly increased. Germany alone has achieved any success with airships, because her efforts and preparation have been extended over a number of years. The cost has been very considerable, but France and England have in the same period expended very large sums of money also on airships without any real gain. Conservatism and false motives of economy caused the money to be wasted, and at the end there was nothing to show but a few slow-speed and antiquated ships which could not oppose the Zeppelins. Although

the gross expenditure of Germany was greater than that of England or France on airships, Germany at least had something tangible for the money, and but for her blunders she might have achieved far more striking results.

From its cost the Zeppelin is limited in number, just as Dreadnoughts are limited, and an expensive and highly equipped establishment must be maintained for its proper working. The hole-and-corner British method of making airships at first a subsidiary branch of the army, and then for some extraordinary reason turning them over as a side show of the navy, is typical of our failure to grasp the needs and possibilities of the new branch of the service.

Speed

The estimates of Zeppelin speed are another proof of our ignorance about what Germany was doing. Not so many years ago a British engineering expert calculated that the Zeppelin could not attain a speed of thirty miles an hour, as he proved by figures that the ship would collapse under the air pressure! At the time this speed had been actually exceeded by a Zeppelin.

To-day the tendency is to attribute too high a speed to the vessels. In still air it is doubtful if a higher speed than sixty-five miles an hour can be reached, and by the most careful computation I have arrived at the conclusion that the average speed of the modern Zeppelin in war trim is about forty miles an hour, with full load. But as the vessel proceeds her fuel load grows lighter and speed increases until sixty miles an hour has been attained for considerable stretches.

Of course with a favouring wind the ship may often be running at over sixty miles an hour, and the difficulty of gauging wind speed often causes erroneous estimates of Zeppelin speed by observers on land. In the upper regions where an airship is moving, there may be a strong current, whilst near the earth there is a calm.

Apart from its structural weakness and its costliness in production and upkeep the Zeppelin is extravagant in power owing to defects in design. Long research into the problem of correct shapes for locomotive bodies has demonstrated the importance of the stream-line form. In the fish, Nature has provided us with an

excellent example of a shape which is adapted for moving through a medium with the minimum of friction.

In its simplest expression the stream-line may be said to be the fish form, that is, a blunt-nosed body swelling out by smooth lines to a part of greatest girth, and then by the same smooth and continuous lines, gradually decreasing in girth to the tail. The idea of the stream-line form is that the medium through which the body travels can stream past it smoothly and unbrokenly. If the body is of irregular shape, with projections and indentations, air eddies are set up which cause friction.

The Zeppelin offends against the stream-line theory in many ways, though the point has been laboured too much by theorists. The chief fault is that the body is of the same girth for its entire length, when it should be fish-shaped ; but equally important is the fact that the propeller brackets project outwardly from the ship's sides, and cause very serious eddies. With a better shape of rigid airship we could undoubtedly obtain a far higher speed for the same engine power.

favourable conditions must offer, for Zeppelins as now constituted. As airship speeds grow higher there will be more opportunities for a daring commander to snatch at.

When the Zeppelin has a definite objective to reach in a limited time it may be said that every weather irregularity endangers success. The ideal conditions for a Zeppelin are absolutely fair and settled weather, prevailing over the whole area to be traversed, and with a very light wind blowing from the east or north-east, giving promise of a continuance of favourable conditions. For day work the sky should be clear and free from electrical disturbances; and for the night voyage, necessary in war work, the sky should be as dark as possible, with a few light clouds to give the ship cover and obscure the starlight.

When Raids are Improbable

We may set out the factors which are inimical to Zeppelin work in war time, and the points will thus serve as a rough guide with regard to the imminence of raids. The Germans are very careful about risking their ships, but sometimes they make mistakes, or the weather plays them

and one vessel has been wrecked by this cause. With an improved design this danger could be minimised.

(3) *Fog.*—In a fog the Zeppelin is blind, and it is liable to make grave errors in direction, which may end in disaster. Ground mists which are prevalent in autumn and winter conceal landmarks from the airship, and make it wellnigh impossible for a vessel to locate its objective.

(4) *Moonlight.*—In strong moonlight the airship forms a target more clearly revealed than under the best searchlight. A Zeppelin would have very little chance of escape from expert gunners on a bright moonlight night, as the vessel is under clear observation all the time it is within range, whereas searchlights can be eluded. The moon is the best illuminator of airships, and in almost all its stages above the horizon it makes a luminous background against which an airship is strongly silhouetted. Exception must be made for nights when heavy clouds wholly obscure the moon; but as these heavy clouds portend bad weather, it is dangerous for an airship to be abroad at such a time.

(5) *Starlight.*—In winter, particularly, and generally on cold nights, the stars can make

a highly luminous background if the sky be unclouded. The Zeppelin shows out against this background to a degree which enables constant observation to be made of its position. Gunners and searchlights can thus readily pick up the target, although it is a very difficult matter to gauge distances correctly in the dim light. A night in which the starlight is dulled by a film of dark clouds, or in other words, a "black dark night," offers the best opportunity for an enemy Zeppelin, provided other conditions such as wind, etc., are favourable.

(6) *Electrical Disturbances.*—In a thunderous condition of the atmosphere, or when the air is highly charged with electricity, a Zeppelin runs great danger. It becomes in itself a collector of electric fluid, and in approaching a cloud also charged with electricity, or in making contact with the earth, there is liability of a discharge taking place which ignites the gas. More than one Zeppelin disaster has been caused by electrical disturbances, and the risk is to be reckoned with during many months of the year, especially in spring and summer.

In going towards England the Zeppelin pilot is travelling in the direction of uncertain weather,

a period of two and a half months, the weather conditions rendered a raid on England impossible. Nevertheless, the lighting restrictions were enforced so severely that traffic fatalities increased enormously in London, and night traffic throughout the country was crippled, causing immense loss.

I have indicated that the Zeppelin as an offensive agent is costly, but it is far less costly in men and money than any purely defensive system which is based on guns. Every citizen killed has a capital value which may be set down at £2000, this sum representing the average earning power and the amount sunk in his or her upbringing and education. When in one year a Zeppelin kills one hundred Britishers and causes another hundred to be killed in traffic accidents due to darkened streets, it destroys £400,000 of British capital, and capital of the most precious kind. Add to this sum the crude money loss occasioned by the injury of hundreds of people, the injury to the health and nerves of thousands, and the destruction of property, and the sums spent in insurances, and it can be realised that the defensive system which allows the enemy to invade one's country is far more costly than any system of offence.

CHAPTER VI

THE ZEPPELIN IN WARFARE

GERMANY has taught us the abuse of the Zeppelin in warfare, and we can trace in it the same evil-directing spirit which has befouled the name of the German sailor and soldier. In the science and technique of war and war preparation the Germans had gained a triumph, which would be admirable if we can admire any part of this man-killing business. But in perfecting her military machine Germany destroyed her civilisation, and with it went many precious qualities incomparably better than military triumph.

Germany could have achieved even greater results in the military as well as the political sense if she had not departed from the rules of warfare. The doctrine of frightfulness is a stupid creed when applied indiscriminately. It is on this doctrine that Germany misused her Zeppelins. Only a wooden-headed German militarist could

believe that a great race like the French or the British could be stampeded into panic because some civilians were killed by submarines or airships.

Quite possibly a small town or a little nation in the last extremity might be terrorised into submission by frightfulness directed against defenceless people. But to imagine that bombs on London, or even the destruction of London could terrify the British race is so absurd that it cannot be generally believed in Germany.

We must seek in other directions for the motives of the German raids. In the previous chapter I have outlined the theory that the raids on England were dictated by the hysteric hatred which the Teuton gives way to under certain conditions. But there is also the grim prompting of ordered destruction.

In the cold-blooded business of war you can weaken an enemy in numerous ways. There is the direct military injury of killing his soldiers, or maiming or capturing them. No less direct is the injury of destroying his wealth, his commerce, his transport services, his prestige, his potential soldiers, his war factories and his supplies. Then in varying degrees of importance we have indirect injuries which include the killing or maiming of

the opinion of neutral nations on the fortunes of the war. Germany exploited the raids upon London as an example of British weakness, and by distorted reports she helped to bring various neutral nations to the belief that the Allies were losing. If at that critical period we had airships capable of meeting the Zeppelins and destroying them before they reached England, our triumph in the air would have been of immense importance.

It would have shaken the German faith in the Zeppelin, and to the neutrals it would have emphasised the impregnability and enduring might of England. In the time of crisis, when we were spending £5,000,000 a day, that result would have been worth at least a day's expenditure. By the outlay of £1,000,000, and the use of a little imagination three years earlier, the requisite effect could have been obtained.

If we accept it that the total damage done by the Zeppelins during the war has been "trifling," let us say a few million pounds, we cannot even then justify our neglect of a similar arm. The men who in past years pooh-poohed the Zeppelin without any exact knowledge of its powers or possibilities acted very rashly, since even with

with devastating effects. Germany would be compelled to set aside a very large number of skilled men to protect the many places of military importance. At sea our naval airships could hunt down submarines and accomplish patrol work of the most valuable kind. The reader will say that the aeroplane can do all this. But the war has demonstrated that the flying machine alone cannot accomplish it in the best manner. It will be opportune here to set out the essential difference between aeroplane and airship warfare.

Aeroplane versus Airship

(1) The aeroplane is a day bird, and as such it is subject to the maximum of observation along the entire route. If he flies so high as to escape observation the pilot loses sight of those land-marks which are necessary for his guidance.

(2) The airship travels by night, and on dark nights can only be detected by the sound of its engines or by the use of searchlights. Engine sound can be considerably reduced, and on a favouring breeze the ship can drift absolutely noiselessly over a dangerous area. As search-lights are mounted at definite fixed points they

(7) The element of surprise is greatly in favour of the Zeppelin, and on a single visit one ship can do more damage than a fleet of aeroplanes.

(8) The airship is far better adapted for long flights over sea.

(9) With a proper system of guns the Zeppelin can successfully fight a number of aeroplanes. The aeroplane enthusiasts deny this, but as Germany has not yet got the right guns the theory remains to be disproved by fact. With machine guns the advantage lies with the aeroplane in daylight.

(10) At night the Zeppelin has nothing to fear from aeroplanes, and it is quite possible to build rigid airships which can equal the fastest aeroplanes and excel them in ascensive power and in gun power.

In this summary comparison I do not seek to imply that the Zeppelin is superior to the aeroplane on all counts, though a correspondingly absurd attitude has been taken up for years past by aeroplane experts in France and England. These men are largely to blame for influencing the authorities against airships of the rigid type, and the war has fully proved how wrong they were.

The most sensible course is to recognise that an aerial fleet must be made up of both aeroplanes and airships, and that each type be specialised for the work in which it excels. Under the widest classification it could be laid down that the aeroplane is for day work and the airship for night work. Starting out from that basis we could then develop each vessel along the best lines.

It will now be accepted unquestioningly that the aeroplane is limited to day use, and during daylight it can be invaluable for scouting, for directing artillery fire, for fighting enemy machines, and at sea for locating mines and submarines. To a limited extent it may be used in raids over enemy territory, but as it is under observation most of the way, and exposed to gun fire, and as it is liable to attack by enemy squadrons of aeroplanes, there is not much opportunity of making a grand scale raid on any point of military importance.

This matter brings me to the subject of reprisals, which has been so much discussed in the British and French Press. It was urged that the one way to stop Zeppelin raids on England was to carry out aeroplane raids on German

upon the aristocratic parts of Berlin might have some little effect, but Berlin is outside the range of the allied aeroplanes, and the approaches to Berlin are so well protected in daylight by the elaborated system of German anti-aircraft defence that any attempt would be a failure.

Had we Zeppelins or super-Zeppelins we could visit Berlin and Vienna—and distribute English newspapers there; but without penetrating so far into the enemy countries we could prevent raids upon England by meeting the German Zeppelins upon the high seas and routing them there. That is at once a policy of prevention and cure. If we failed to find the Zeppelins and destroy them at sea we could still patrol our coasts and the approaches to London; and if by some superior strategy the Germans stole through on a few occasions we could yet have the power of making reprisal attacks on Krupps', and on Potsdam if need be.

Under the aeroplane regime we were helpless both in attack and adequate reprisal. We were compelled to fall back upon a costly and insecure defensive which required a large force of men and guns on constant duty, and this system inflicted a hardship upon the citizens in that

towns were darkened to a dangerous degree, occasioning many traffic fatalities.

In effect, Germany, by an occasional feint raid and demonstration within sight of the newspaper reporters in Holland, pinned us down to a continuous and dangerous defensive which took almost as big a toll of British life as the raids themselves.

No stronger argument could be put forward to prove the value of a vigorous offensive. It was admitted in the House of Lords debates (1915) that even the concentrated defences of guns and searchlights around London were not proof against the enemy attacks, and Lord Sydenham, speaking from military experience, dealt very frankly with the difficulties which gunners experienced in shooting at Zeppelins. With the facts of the raids before him he refuted the claims which for years previously the artillery theorists had made with regard to their guns. The war proved that for the first year at least, the gunners had little success against aeroplanes by day or Zeppelins by night.

This does not mean that the gunners are beaten. It merely implies that they lost the first round of the contest which ever ranges between

target and gunner. The high-speed aerial target was too elusive for the guns of 1914–1915, but invention was active to readjust matters, and we can be quite sure that as the war proceeds the margin of safety for aerial craft will narrow down.

It was rather erroneously held that Britain's defenders were peculiarly at fault in 1915, and it was the habit to hold up the air defences of Paris as a model of perfection to imperfect London. In justice to our aerial defenders the situation deserves elucidation. Paris was never seriously attacked by Zeppelins, because there was no special object, politically or morally, to call for it.

The Germans have never been so vindictive against the French as against the British, and the effect of bombing Paris would be as nothing compared with an attack on London. The conditions, too, were totally different, and altogether in favour of the French capital. Paris lies in an open plain. It is surrounded by rings of forts, and beyond that is the great battle line studded with anti-aircraft guns. To reach Paris the Zeppelin would need to pass over land where it could be liable to detection almost the whole way.

London, on the other hand, is an open and unfortified city, straggling far and wide over

us with expert aerial gunners equal to, or even better than, the Germans, I am told.

In stating that an airship or aeroplane drops its bombs in a vertical plane we must not assume that the missile falls in a straight line, or that the aerial vessel must be directly over the object it wishes to strike. The aeroplane must always maintain a high speed, and if we take its velocity to be forty miles an hour at the moment of dropping a bomb, it is evident that the bomb has a horizontal speed of forty miles an hour at the moment of its release.

This horizontal velocity carries the bomb forward, and then in conjunction with the downward pull of gravity the bomb traces a parabolic curve in the air. Hence when an aerial vessel desires to bomb a building it releases the missile before getting directly over the target. The distance of release depends upon the speed of the vessel principally, and it is evident that very great skill is required for accurate bombing. It may comfort a terrestrial observer that when an aeroplane or a travelling Zeppelin is directly over his head it cannot strike him with a bomb. The period of danger is when the aircraft is within a couple of hundred yards of him, and he is in the

direct line of advance. The higher the altitude of the ship and the greater the speed the more difficult becomes the problem of bombing. Small bombs are also subject to wind deflection and are less certain in their aim than large bombs.

On the whole it may be said that the Zeppelin is a better shooting instrument than an aeroplane at the same altitude, for the airship may slacken speed or even hover near its target, but the aeroplane is always moving rapidly in relation to the earth.

French and British airmen have cultivated the daring habit of diving very low when about to bomb a place, and by swooping down to, say, five hundred feet they ensure far greater accuracy of aim. They run tremendous risk, however, and as gun fire improves it is to be feared that this manœuvre will not be so feasible as in the past.

To ensure reasonable safety the aerial vessel needs to be at a considerable height, and it must have the powers of rapid acceleration and quick change of position, as well from side to side as in an up-and-down direction. In one respect the airship is here unique, for the very act of dropping a heavy bomb causes the ship to rise suddenly and automatically for about thirty feet vertically in

been made to the top, and here a little platform is set out for machine guns which could ward off aeroplane attack from above. This experiment must have proved dangerous, for it has to be borne in mind that an airship is always exuding hydrogen gas from its pores, and this gas mixed with air forms a most explosive mixture which streams upwards and surrounds the ship like a halo. The firing of a gun from the top of the Zeppelin would tend to ignite this gas, and the operation was thus a risk which did not commend itself.

We may anticipate that this difficulty will be overcome, and there will be few occasions when a Zeppelin need allow an aeroplane to rise above it, for in quick ascension the airship has the advantage.

We must also consider the imminent possibility of airships carrying guns which will fire small shells at long range. With a few guns of this type in the lower cars and in the upper platform a Zeppelin could fight an aeroplane just as a Dreadnought might combat a small cruiser.

Another trouble with gun fire from airships is the recoil, but there has been invented a new aerial gun which claims to eliminate this.

Conceive a miniature airship carried by the super-Zeppelin. This miniature airship or aerial torpedo has its engine, steering planes, control system, and explosive charge. Most probably it would be a blend between airship and aeroplane practice, for it need not be lighter than air. In this manner it could carry a serviceable charge of explosive without being made too big.

Its function would be to travel, on release from the Zeppelin, under its own power and the force of gravity on a gradually inclined pathway with sufficient speed to make an accurate course. Possessing the advantage of being discharged from a high altitude it would have opportunity to develop a momentum which would make it a formidable projectile. Steering control by "wireless" would permit the gunner to regulate the course of the torpedo as it sped on its way.

An airship armed in this manner would approach to within about five miles of a city, and then from a height of, say, a mile, it would launch its torpedoes. The first might be of an incendiary nature to illuminate the scene, and after this alarm the searchlights of the defenders would give more light as they scoured the skies for the airships. It should be no more difficult to hit

high-speed ship is most serviceable in surprise work, as, for example, at the very opening of hostilities. If one power possesses a fleet of airships ready mobilised at that time she can deliver a powerful blow to an enemy who has no similar vessels. Germany lost her great opportunity in the first weeks of the war when the English anti-aircraft defences were at their least developed stage.

A power, without sinking to the dastardly tactics of Germany, could use its ships in attacking camps, convoys, troops, ammunition centres, railway junctions, and other points of activity. With a sufficiently large fleet serious confusion could be created in the enemy's mobilisation arrangements.

Germany did not adopt these plans in 1914, for the simple reason that she had not enough ships for the purpose. She made no air raids on England for the equally sound reason that she was not then prepared for the task. In this way the inaction of the Zeppelin fleet during the early part of the war can be explained. There was no real need to use the ships against France, and if Britain had remained neutral, it is highly probable that the Zeppelins would have taken little

part in the war of 1914; but they would be prepared, increased, and improved for the subsequent war with England, when Germany, from her conquered provinces of Belgium and Northern France, would strike her final blow for the conquest of Europe.

The simple and prompt decision of the British people not to stand aside spoiled the German plan, and incidentally it prevented the Zeppelins from being used in the manner designed. Under the altered arrangements a new plan of campaign had to be worked out for the airships, a plan of revenge against England; and we have seen the fruits of that scheme in the raids, the first of which did not take place until the war had been many months in progress.

If Germany had been quite ready with her Zeppelin plans in 1914, the most favourable months for action against England were from August to October, 1914; but my theory is borne out by the circumstance that she did not make any serious attempt until the following year.

I dwell on that matter to show that the use of the Zeppelins by Germany in 1914–1915 was not the best mode of employment from a military, or even a political sense. It is important to show

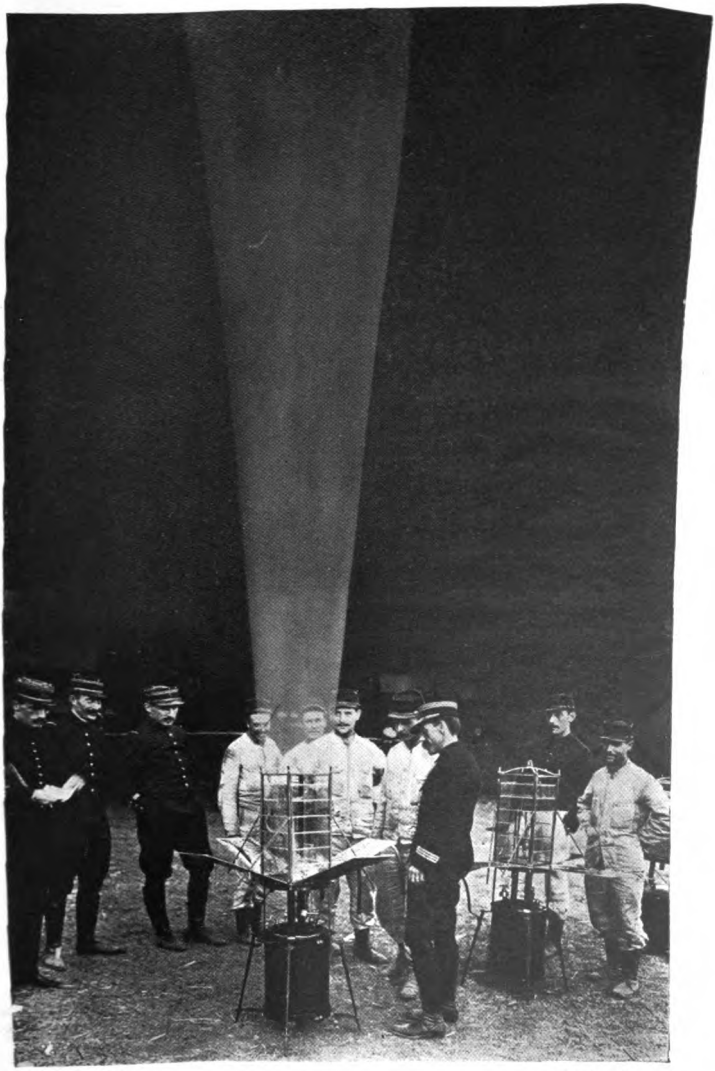
this, for we will have critics again asserting that Britain does not need airships of the Zeppelin type. They will maintain that the Zeppelin was a failure in the war, and they will attempt, as in the past, to dissuade the Government from building these vessels for our future protection.

My main purpose in this book, as in my writings on airships for the past ten years, is to demonstrate the necessity for us to have these vessels. Even if it be granted that in a future war we could do relatively little with our air fleet, we must never allow ourselves to be reduced to that state of helplessness and humiliation when we watched the Zeppelin raiders over London for the first time. National pride alone should make us build airships which would enable us to command our upper air by night as by day.

We all wish most devoutly that there will be no "next war," but after the needless sacrifices, entailed by our past remissness, we must never again allow any other power to stride ahead of us in the new inventions and technics of war.

Scouting

It is not generally realised that the Zeppelins were largely utilised from the outset of war for



By courtesy of *"The Sphere"*

GUIDING THE AIRSHIP

A French night signal for aerial vessels. In Germany regular lighthouses have been erected at various points as landmarks for Zeppelins at night

most costly and least effective mode of fighting an aerial enemy. At best it can only beat him off or scare him away from a few places. A fleet of ten Zeppelins employing directly and indirectly an establishment of 500 men might require a special force of at least 5000 men with numerous and costly guns and appliances to guard a few towns against them, and this force might be unable to destroy a single airship during a series of raids in which hundreds of lives could be destroyed. The actual establishment expenses of the land force, plus the money value of the damage accomplished by the raid, would far exceed the cost of building a fleet of airships.

The initial cost of the airship fleet would be greater of course, and in public affairs we generally prefer the penny wise pound foolish policy. The cheap plan of defence finds most favour in time of peace, and when war comes there is the inevitable attempt at improvisation, money then being spent in the most reckless and foolish fashion in the vain attempt to achieve miracles. General Joffre's motto, "You can never improvise in war," might be written over every Government office.

The Best Defence

It will always be a cardinal rule in warfare that the best defence is a highly developed and vigorous offensive. In no branch of war is this more important than in aerial warfare. Entrenchments may hold off an army, submarines and mines may check a navy, because in land and sea warfare the attacking forces have but relatively few routes of approach. But aircraft have almost unlimited scope, as they can attack from any direction and from a great variety of altitudes.

Fixed defence for anything but a country of the smallest area must thus resolve itself into the defence of a few important points, leaving the rest of the country fully exposed to bombs, aerial torpedoes, or any other missiles the mobile attackers may choose to employ.

Without more ado it can be said that to fight Zeppelins it is imperative that the attacked nation should have Zeppelins, and if decisive victory is required it is necessary that the defending power have super-Zeppelins. In the next chapter I shall define what these vessels may be. But here I might hint that the best way to obtain super-Zeppelins is to build successful Zeppelins first.

In fighting Zeppelins by Zeppelins the matter resolves itself into a fairly simple war problem. The side with the most ships, the best ships, and the best men almost invariably wins. It is one of the few safe calculations in war. With a fairly evenly balanced fleet the issue is decided by the men, although in this case luck must be allowed for.

But if England had set out in the Great War with even five Zeppelins, and acted on a wholly defensive rôle, it is tolerably certain that she could successfully guard Britain from German raids. With any fair chance our men are better in this class of warfare, and the difficulties of attack are so great that Germany would have by far the more risky part.

Assuming that Germany had twenty Zeppelins at the outset and England five, we should still expect that in the preliminary stages Germany would send out only two or three ships at a time in order to gain the necessary experience. This cautious policy would give the defenders excellent chances of whittling down the German numbers.

If, on the other hand, Germany staked all on a big attack, and sent out ten ships, her air

admiral would find it a wellnigh impossible task to keep his whole fleet consolidated and up to the uniform speed required for a successful raid across the North Sea. The ships would necessarily start fully laden, and thus would be slow and at a low altitude. With our sea power giving us fuel stations in the North Sea we could use one or two of our Zeppelins to attack on a half-fuel load. In other words, with a lighter burden of fuel our ships could climb higher and show greater speed. Hence they could rise above the fully laden German ships and attack from the superior upper position. This form of tactics is peculiar to air war, and it gives an almost decisive advantage to the vessel which has the upper station and the higher speed.

With our ships scouting off the German coast it would be exceedingly difficult for a German air fleet to set out without early detection. Our ships could then give the warning to the navy, and at the same time harry the German fleet, always alert for the vessels which showed signs of dropping away from the main fleet.

Under conditions like these it is probable that a German fleet of ten Zeppelins would

be so worried by the British airships, aided by the navy and by seaplanes, that serious losses would be incurred long before the English coast was sighted. Every mile would add to the dangers and difficulties, and the timely warning given by our Zeppelin scouts would enable us to have an overwhelming concentration of gun power ready. It is inconceivable that the German fleet could successfully raid England under these conditions, and the probabilities would be in favour of the annihilation of the entire fleet.

Contrast that with the happenings in 1915, when time after time the Zeppelins stole across the North Sea in daylight and reached England unscathed. It will be asked why we had not fleets of seaplanes scouring in the North Sea. But they would not have availed, for they have not sufficient range of action to work from a floating base near the German coast, and they have not the same facilities for wireless communication and independent action.

It is true that our airship scouts might be eluded by the enemy crossing over Holland or Belgium, but the remainder of our fleet would be in patrol along our coast, and with their superior speed and wide range of action they could quickly

intercept the enemy, or at least force him to a most dangerous circuit over France, down the Channel, or far north. Any of these manœuvres would practically spoil the enemy's raid, as so much fuel would be used in the circuitous route that there would not be enough remaining to carry out the original plan.

As a final defence we could have one or two fast ships cruising within fifty miles of London, and in direct touch with all the observation stations. These ships could attack and destroy any enemy ship which might have got through the outer defences. The acute critic will ask how the ships are to see each other at night? But to explain how detection can be made feasible, I should be revealing a little secret in aerial strategy which has not been grasped yet by many of the experts.

A fleet of only five super-Zeppelins, skilfully handled, could ensure the safety of England from Zeppelin attack, even if the enemy fleet numbered twenty Zeppelins of the modern type. Acting on the defensive the super-Zeppelin has advantages somewhat similar to the submarine, and a raid is made very difficult. Riding very high a defence ship has a wide range of action. Once the

searchlights found the enemy ship at a lower altitude our vessel could quickly attack from overhead with every certainty of success.

The main objection to a super-Zeppelin fleet is the initial cost, and it is a faulty trait of the English that we are rather fearsome about putting down much money on a new enterprise. We will waste an infinity of small sums in futile experiments instead of doing the big thing right away.

A super-Zeppelin could be built for less than £30,000 under a well-planned system, and a fleet of five ships would cost £150,000; but we should require to put down at least £400,000 for factory equipment, harbours, weather stations, etc., if the scheme is to be worked effectively.

An Air Service wholly distinct from army and navy should be created, calling into service new types of men. Perhaps £1,000,000 would be required to start a proper air service, and it is to be feared that the public would stand aghast at this sum. But they might spend millions in gun equipments, army and navy anti-aircraft services, and yet expose the country to a succession of raids which would cause heavy loss of life and incalculable damage.

It may be held by critics that guns and searchlights can be so developed that they will master the Zeppelins. Night shooting against Zeppelins is more difficult, however, than daylight bombardment of aeroplanes. The searchlight itself is of limited and uncertain value in finding objects in the sky, and under certain atmospheric conditions its powers are greatly curtailed. Yet for this highly specialised shooting, which called for the most thorough training in the battle line, we deputed many raw amateurs in the early period of the Zeppelin raids!

Rather unjust criticism was levelled at British gunners because we failed during 1915 to bring down any Zeppelin raiders. Undoubtedly some of the shooting was shockingly bad, but we must blame the system which put the wrong men at the guns.

A gunner, first of all, must understand the habits of his target. But very few people in England knew anything about the habits of Zeppelins. We had contemptuously neglected this branch of study, and neither the gunners nor their superiors had exact knowledge.

The Zeppelin is a most elusive object despite its size. It can leap upwards in the air at

astonishing speed. It can drop rapidly. It can climb at a steep angle. It can dive wonderfully, and it can nose from side to side with no mean agility. To reckon its altitude at night is most difficult, and to find its range is a matter of much nicety. The Zeppelin has far greater jumping power in the air than an aeroplane, that is it can change its position up or down more rapidly. This matter is most disconcerting and strange to the gunner who is only trained for rapid change of position from side to side in the same plane.

Years of special practice with special guns, the men being trained by experts who knew the principles of the Zeppelin thoroughly, were necessary to make a serviceable land defence against the Zeppelins. This department would have cost quite as much money as a super-Zeppelin fleet, and there is no evidence to show that it had been established in this country. Our fatal lack of imagination prevented us from looking ahead.

Even if we had promptly elaborated a land-defence system which provided thousands of searchlights, guns, and expert gunners, we should still be under the disadvantage of the fixed-point defence system. Short of putting a gun, a searchlight, and a staff of gunners at intervals of

aeroplane experts that the airship could not keep the air against aeroplane attack. The boast was semi-officially made in this country that if Zeppelins visited us we would send a "cloud of hornets" against them in the shape of aeroplanes. The Zeppelins came; but the "hornets" were powerless at night, as every intelligent student of the problem foresaw. It has now to be admitted that at night the airship is virtually unassailable by aeroplanes, and thus even if it be of inferior fighting power it has a safe period of action during which it is free from aeroplane attack.

Just precisely why an aeroplane is all but useless for night fighting is not clear to many people. We must first consider that the aeroplane rises and keeps flying by the action of its engine. When the engine stops the machine falls to earth. Generally speaking an aeroplane must have a prepared ascending place and landing place, especially if a night flight is attempted. To come to earth in the darkness would be disastrous, for the aeroplane is running at high speed when it touches the ground, and it must continue running for some distance uninterruptedly in order to lose its momentum.

Once safely projected into the air a flying

machine could keep in flight, but unless it could reach a prepared landing place it would need to keep flying until daybreak. During winter this would necessitate a flight of perhaps eight hours' duration. Any failure of the engine power entailing a forced landing would mean almost certain death for the pilot.

It is often suggested that the night-flying aeroplane might carry powerful lamps, and thus light the ground for its own guidance, but this plan is not practicable, since no form of artificial light can reveal the nature of unknown ground properly to the pilot.

To fight a Zeppelin at night an aeroplane must rise from a prepared place. If descent be necessary before dawn a return must be made to this special place, which must be lighted up if the pilot is to avoid disaster. The whole operation is so dangerous that it is almost sending a man to death to order him aloft on a dark night. Yet, in their ignorance, the higher authorities had accepted the theory that the aeroplane was suitable for night attacks. They should be wiser now.

Granting, however, that an aeroplane can ascend at night there is little hope that it can find out or fight a Zeppelin. The aeroplane pilot

seeks his object by virtue of his eyesight. But on a dark night he has only a remote chance of finding a Zeppelin. Observers on land are guided mainly by the sound of the airship, but the aeroplane pilot is deafened by the noise of his own engine, and the sound he makes will also have the effect of disconcerting the land observers whose ears and microphones are ready for the enemy.

Even if the aeroplane pilot discovered a Zeppelin he would be so handicapped by his limited range of vision that he would have small possibility of manœuvring successfully. At the same time by his position he might prevent the guns on land from acting, and he would probably run more risk than the Zeppelin of being shot down.

Until we can have a very large and powerful aeroplane fitted for ten-hour trips in the air, and equipped with powerful searchlights and guns there is little possibility of the flying machine challenging the Zeppelin at night. To meet this super-plane, the Zeppelin will no doubt develop its gun range, and it will be always superior in rapid ascensive power to the big flying machine.

A most important point to remember with

many limitations are imposed. In a subsequent chapter I deal with other aspects of the super-plane, but it is necessary here to point out that no great hope can be based on the super-plane as a vessel for fighting the Zeppelin at night. It is in daylight service that we must look for best results with the super-plane.

Defence of Towns

It is only fair to say that fixed or land defences can be made quite effective for what in aerial warfare we may term a point, or, in other words, a town. Gun and searchlight defence is feasible for a great city, and straggling and wide flung though London be it is by no means impossible of excellent defence.

Given a sufficiency of suitable guns, expert gunners, and searchlight operators, controlled by an administration which understands the problem, and no Zeppelin need ever be permitted over London. There is no magic in the affair. It is a fairly simple, straightforward—and expensive—job. But it is a task which cannot be suddenly improvised, and above all it must be done on a grand scale.

CHAPTER VIII

AIR RAID PRECAUTIONS

THE responsibility for precautionary measures against hostile air raids rests almost entirely upon the Government and its military advisors. The public are practically helpless. An administration which knows its work, and prepares for eventualities, can provide a very high degree of protection for every citizen; and the essence of military power is to afford this protection. We may always suspect something defective in the administration of a great power which allows an enemy to readily pierce its lines of defence.

A series of enemy air raids implies that the enemy has penetrated the battle line which guards the nation. To give full protection to the people we should have land, sea, and air battle lines which would be impenetrable. Air raids are the most difficult to guard against, but they are the most dangerous since they can be most frequently made, and also for the reason that the aircraft

can attack a greater variety of places than sea or land raiders.

In future wars, even though Germany may not be one of the combatants, it would be most unwise to trust in the chivalry of the enemy, with regard to the bombing of open towns. War is a brutal work of blind destruction, and as the range of weapons extends there will be an increasing difficulty in avoiding the slaughter of women, children, and other non-combatants.

Most probably the wars of the future will be mainly and deliberately based on economic pressure, starvation, destruction of food supplies, munition works, and national wealth. Government centres, business areas, factories, strategic railways and ports will be aimed at, and for most of these purposes aerial fleets will be used. The strategists, in directing great shock blows at the national nerve centres, will be indifferent to the number of non-combatants involved in these attacks. War will be more an affair of nation against nation than of soldiers against soldiers.

A power setting out with chivalrous notions may be compelled to copy the tactics of an unscrupulous enemy, if the latter gains any great

military advantage by some new move. The reluctant use of noxious gas by the British army in the Great War is an example of how the rules of warfare must be modified by military necessity.

If citizens are to have the maximum of security they must demand from their Government a highly developed aerial battle line. Land and sea forces must be supplemented by a new force whose duty it is to hold command of the air over its country. It will be disastrous for a great nation in future to neglect the air fleet, for no matter how successful its land and sea forces may be they will be powerless against air raids from a well-prepared enemy.

The war of 1914 came about before aerial vessels had been highly developed, and before their strategy had been worked out. The number of vessels was too small to admit of anything but local operations. Available supplies of aeroplanes, for example, were required for scouting purposes and artillery direction over the battle lines, and for occasional raids on points in the fighting area. No power had sufficient reserve of machines and pilots to carry out those massed raids which we must expect in future wars.

So, too, with airships, there was not a sufficiency of vessels to produce any big result. Had Germany possessed a great fleet it would have been as easy for her to send twenty or forty Zeppelins over London as the two or three ships which appeared there. With England as ill-prepared as she was in 1915, the dropping of from forty to eighty tons of explosives on the capital would have been possible, and the results would have been appalling.

We must look forward to the possibility of an enemy sending aeroplanes by the hundred against our towns in daylight, and at night we shall be menaced by great fleets of super-Zeppelins numbering from ten to fifty. Hence we must anticipate that bombs and other agents will be rained upon us by the thousand.

Intense bombardment of this nature, supplemented by aerial torpedoes and other fiendish devices, will wellnigh smother any feeble system of land defences depending upon isolated guns and searchlights.

The only safe precaution will be to develop an aerial navy just as we build up sea and land forces in relation to the enemy's strength. If the citizens insist on a grand aerial navy which gives

us the power of offence and defence against any possible enemy force, then we need not trouble about buying Zeppelin insurance policies, or reducing the lights in towns, or adopting the various other childish measures which proved so vain in past raids. Our aerial defences will be settled off the coast by our air fleet.

If we are defeated because our ships, our men, and our methods are inferior, then we shall be beaten out of the air, and we shall have to fall back on our land defences. Here again we must have a highly developed system of special guns, observation stations, etc., designed to ward off the raiders before they can reach the vital centres of the nation. The defences of London, for instance, will not be in London, for a determined enemy might deliberately allow a portion of his fleet to be "sunk" over London owing to the immense damage which a big ship laden with explosives and fire agents could occasion.

Were an inferior fleet of ours beaten out of the air, and did we then fall back upon a badly arranged gun defence of London, an enemy with a big fleet of aeroplanes and super-Zeppelins could render the metropolis uninhabitable. By day and night the rain of fire and explosive would

to have underestimated rather than overstated the case. My present estimate of the potentialities of aerial fleets in future wars is an equally careful attempt to avoid making exaggerated claims.

In the present war the authorities and the people have been taken by surprise, and we are sheltering under a hastily improvised system of defence. For the moment little more can be done beyond increasing the number of guns and improving the skill of the gunners. This has now been done as regards London and some other centres, and the most critical stage has been passed, I hope. Germany has not sufficient Zeppelins to carry out a real campaign, but with her few ships she has taught us a lesson which must not be forgotten.

For the citizen himself there are few useful precautions to suggest when enemy airships threaten him. Most people now overestimate the danger, and minor officials are apt to take panic (persecuting the people instead of protecting them). As I have shown, a small fleet of Zeppelins can operate only on rare occasions, and it is certainly not worth while on balance to plunge London into dangerous darkness every night of the year in the ostrich-like policy of

situation. Indeed I should not be surprised if Zeppelin raids will cease long before the war is over, for as soon as the official German intelligence wakens to the fact that each futile raid is but piling up the bill against Germany there will be a change in policy.

But so mysterious is the German mind that we can afford to take no risks in slackening our defences or precautions. The citizen must be very careful in traffic every night of the year. On three or four dark, windless, and rainless nights each month he may indulge in the fancy that "Zeppelins will come to-night," and order his habits accordingly. That is, he will stay at home and occasionally look with new speculative interest at the clock some hours after darkness has fallen.

Let him sit comfortably by his fireside, and between intervals of looking at the clock, dipping into some cheerful book, or drawing comfort from his pipe, let him moralise upon the madness of war.

Perchance as an intelligent unit he may spread the philosophy that if we can beat down militarism we can beat down war. But let him not lose sight of the governing fact that Life itself is

over this country and we could not send a single ship to fight them.

That the Zeppelin is crude is obvious, but it is not easy to improve upon it, and certainly we shall not arrive at improvement by haphazard, rule-of-thumb methods which are always stinted by lack of funds. The Zeppelin has only been brought to its present development by persistent work on scientific lines. The capture and total dissection of a Zeppelin will not be sufficient to reveal all the secrets of the Zeppelin to men who are not experts in airship matters. Anyhow, we must be something more than mere copyists. But that the Zeppelin crudities can be overcome I am certain, provided we set about the task in the right way.

With an appreciably faster and stronger vessel, a much wider range of usefulness will lie before the super-Zeppelin. The great ship of the future will have a still-air speed of at least 100 miles per hour, so that on most nights of the year it can be in action. With more efficient engines it will have a range of about 1000 miles, and thus, practically, every part of Europe will be within reach. Larger ships of 2000-miles' range will bring the Atlantic passage

By means of its high speed the super-Zeppelin can defer leaving its base until night time. Thus a British ship, planning to raid Kiel, would not set out until night had fallen. It would pass over the North Sea and Germany unobserved, and reach its destination within four hours.

Absolutely unheard and unseen it would hover over its objective for a direct bombing, and consequently would have the immense advantage of giving the first blow. The German port might be in semi-darkness, but this would not save it, and after the first bomb fell the searchlights would come into operation, lighting up the scene. With one airship high overhead to draw the searchlights and gunfire, the rest of the air fleet might be some miles off sending in aerial torpedoes.

Before daybreak the ships could be back in England again.

In a future war we have thus to conceive that a nation with a fleet of super-Zeppelins will have the power to strike at another nation with the utmost suddenness. An unscrupulous power can declare war by a massed night raid on the capital city, or on the chief ports or mobilising centres of its victim.

field of view greater than any sea scout can possess.

Warships at night will be menaced also, for if they show any light they may be bombed. Flare-light bombs may be thrown to show the position of the ships, and then they can be attacked by aerial torpedoes. Warships using their searchlights for naval purposes will be targets for aerial attack, and it may well be that the night battle of the future at sea will involve airships as well as seaships.

The critics will say that it is a far cry to all these developments. But the Zeppelin is only ten years old now, if we reckon from the time when really practicable petrol engines gave it the necessary power. Within the next ten years there will be great strides made in every branch of aerial engineering, so that the airship certainly will progress.

So convinced am I of this that I believe we shall have commercial super-Zeppelins eventually. The speed of seaships is advancing but slowly and with enormous expenditure of energy. It is to be doubted if in ten years' time any steamer can average as much as fifty miles per hour. But it is most probable that the hundred-mile-an-hour airship will have then become a fact.

SUPER-AEROPLANES

A vehicle which can accomplish a journey on most days of the year in one-half or possibly one-third of the usual time will attract many people, and there is no reason why the risks should be greater. Ultimately, indeed, aerial traffic promises to be the safest form of really high-speed transit. It will have its limitations and special dangers, needless to say, but the speed-loving people of the future will hardly be deterred from a form of locomotion which will have so many obvious advantages over train and steamer travel.

The Super-Aeroplane

The super-aeroplane will probably be the companion of the super-Zeppelin. Here again speed is the great end aimed at. Already the various Powers are testing large aeroplanes, some of which mount no fewer than four engines, and promise very high speeds.

One of the most interesting of the new vessels is the "battleship-aeroplane" now being constructed by the famous American designer Curtiss. This aeroplane has a width or span of 135 feet, which is considerably greater than that

of any other vessel yet built. The planes rest on a central boat-shaped body, which provides accommodation for three engines, a crew of eight, and supplies for 700 miles. The total weight of this super-plane is 10 tons, and it can carry about 3000 lbs. of ammunition. There are three propellers, and very high speeds are expected. It is far and away the best design of super-plane yet evolved. The cost of construction is £20,000, so that it is not much cheaper than a Zeppelin.

There are many advantages for the war super-plane, but it has its drawbacks also. In planning this vessel we must increase dimensions and weight in order that more powerful engines may be fitted. For each horse-power gained we pay heavily in added weight and resistance area. From Nature we have the analogy that the bird form of structure is not carried to the same grand scale attained by fish and land animal forms. There are few birds of very wide area of wing, and they are mostly sea birds which cultivate the art of soaring in strong and steady winds peculiar to certain regions.

The high-speed birds are small, two of the most representative types being the swallow and the racing pigeon. It remains to be seen if man

can mount big and heavy engines on a large and heavy aeroplane, and obtain a safe and fast vessel. With every flying machine the most critical operation is that of landing, and the heavier the machine is, the more dangerous is this task. When we arrive at the stage of aeroplanes over one hundred feet in width and weighing several tons we come to a very delicate task in bringing this monster to earth. On water the task will be easier, and it may prove that super-planes can be best devised for oversea traffic. I have made investigation with the bicycle, motor cycle, light motor car and heavy motors on this problem of landing shock when a wheeled vehicle travelling at high speed leaps from the ground and comes to earth again. As might be expected the shock is most serious with heavy vehicles, and it looks to me as if the heavy super-planes weighing from eight tons upwards cannot be safely brought down on land owing to their great weight and momentum.

If the super-plane be wellnigh confined to overwater traffic it follows that from the military standpoint the super-plane cannot pursue a Zeppelin over land at night, as a descent for the flying machine would be fatal. It is also doubtful

if the super-plane can excel the super-Zeppelin in speed.

I cannot get away from the belief that the inherent buoyancy of the airship is an immense advantage, as compared with the necessity for descent which is enforced upon every flying machine when its engine fails. Duplicate engines may improve matters very much, but there still remains the obligation for the aeroplane to continue moving at high speed in order to keep aloft, unless indeed the vertical screw can be developed to keep the vessel hovering.

The future may conceal from us some composite type of vessel which has the airship's power of floating in its medium, and at the same time has the special advantages of the super-plane. But we shall only arrive at that type by a very thorough trial of both the airship and the aeroplane as we know them to-day. Chemists may produce for us new and safe gases to replace the dangerous hydrogen: engines will be vastly improved, and a new school of engineering will assuredly evolve marvellously light and strong structures which will be the hulls of super-airships.

Out of the wars and passions of to-day, out of the preparation of men to kill each other

by every scientific device, there will ultimately grow a sane spirit of Internationalism, and between the peaceful nations of the earth the super-airship then will be a busy shuttle of intercommunication. So may the great science of Aerial Navigation justify itself by good service to mankind.